A national quality incentive scheme to reduce antibiotic overuse in hospitals; evaluation of perceptions and impact

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A national quality incentive scheme to reduce antibiotic overuse in hospitals; evaluation of perceptions and impact.

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Short title: Perceptions of hospital quality incentive for antibiotic use

Structured Synopsis

Background: In 2016/2017, a financially-linked antibiotic prescribing quality improvement initiative (AMR-CQUIN) was introduced across acute hospitals in England. This aimed for >1% reductions in Defined Daily Doses / 1000 admissions of total antibiotics, piperacillin/tazobactam and carbapenems compared with 2013/2014 and improved review of empiric antibiotic prescriptions.

Objectives: To assess perceptions of staff leading antimicrobial stewardship activity about the AMR-CQUIN, the investments made by hospitals to achieve it and how these related to achieving reductions in antibiotic use.

Methods: We invited antimicrobial stewardship leads at acute hospitals across England to complete a web-based survey. Antibiotic prescribing data were downloaded from the Public Health England Antimicrobial Resistance local Indicators resource.

Results: Responses were received from 116/155 (75%) acute hospitals. Due to yearly increases in antibiotic use, most trusts needed to make >5% reductions in antibiotic consumption to achieve the AMR-CQUIN goal of 1% reduction. Additional funding was made available at 23/113 (20%) trusts, and in 18 (78%), this was <10% of the AMR-CQUIN value. Nationally, the annual trend for increased antibiotic use reversed in 2016/2017. In 2014/2015 year-on-year changes were +3.7% (IQR[-0.8, +8.4], +9.4%[+0.2, +19.5] and +5.8%[-6.2, +18.2] for total antibiotics, piperacillin/tazobactam and carbapenems respectively and +0.1%[-5.4, +4.0], -4.8%[-16.9, +3.2] and -8.0%[-20.2, +4.0] in 2016/2017. Hospitals where staff believed they could reduce antibiotic use were more likely to do so ($p<0.001$).

Conclusions: Introducing the AMR-CQUIN was associated with a reduction in antibiotic use. For individual hospitals, achieving the AMR-CQUIN was associated with favourable perceptions of staff and not availability of funding.

Introduction

Antimicrobial consumption is linked to antimicrobial resistance (AMR) both in populations and in individual people.[1,2] As much as 50% of human antibiotic use may be unnecessary[3] and reducing this overuse is a major priority in healthcare systems across the world.[4,5]

In the United Kingdom NHS, hospitals are responsible for a minority of total antibiotic use but they are almost exclusively where the most broad-spectrum antibiotics such as piperacillin/tazobactam and the carbapenems are prescribed.[6] Avoiding antibiotic overuse in hospitals is challenging because patients with clinically significant bacterial infections require prompt administration of effective antibiotics, almost always before definitive diagnostic information is available. Initiatives to prevent avoidable deaths from infection encourage rapid administration of reliably active antibiotics to patients who meet broad clinical criteria for sepsis; however, many of these antibiotics are subsequently deemed unnecessary.[7] Despite a succession of initiatives in the NHS, such as increased funding for antimicrobial stewardship (AMS) (2003),[8] a requirement in law for hospital trusts to ensure appropriate antimicrobial use (2008),[9] and development of an Antimicrobial Toolkit for English hospitals called 'Start Smart Then Focus' (SSTF) (2011),[10] antibiotic use in National Health Service (NHS) hospitals has increased, year-on-year up until 2014.[11]

In 2015, NHS England required Clinical Commissioning Groups to submit their local baseline prescribing data to enable validation of prescribing patterns and antibiotic use.[12] The following year saw the introduction of the first Commissioning for Quality and Innovation (CQUIN) for antibiotic prescribing (AMR-CQUIN).[13] CQUINs are the main mechanism by which the NHS encourages hospitals to focus on the quality of care delivered by making a proportion of income conditional on achieving specific quality measures. The AMR-CQUIN was worth 0.25% of acute trust income (approximately £650,000 for an average size hospital based on the number of inpatient beds). Given the emphasis in SSTF on review and revision of antibiotic prescriptions as a key activity to control antibiotic use in hospitals, the four AMR-CQUIN components included empiric review of >90% of antibiotic prescriptions within 72 hours along with reductions in antibiotic use (defined daily doses per 1000 admissions) of ≥1% compared with baseline (2013/2014 data) for 1) total antibiotics 2) piperacillin/tazobactam and 3) carbapenems.[13] Hospital trusts were required by NHS

74 England to submit antibiotic consumption data to PHE for the preceding years, 2014/2015
75 and 2016/2017, and received an additional payment for the submission of this data. All data
76 submitted were published on the 'Fingertips' Antimicrobial Resistance (AMR) Local Indicator
77 data portal as part of the English Surveillance Programme for Antimicrobial Utilisation and
78 Resistance (ESPAUR).[14] Fingertips provides access to a wide range of local public health data
79 presented as thematic profiles. It acts as an important national repository of data on
80 antimicrobial use, AMR, infection prevention control data and hospital acquired infection
81 data.[15] Following the introduction of the AMR-CQUIN, AMS leads at individual hospitals
82 anecdotally reported varying success in securing financial investment to support achieving
83 these quality improvements and expressed anxiety about achieving the antibiotic reductions
84 needed to meet the AMR-CQUIN. The aim of this study was to establish how the AMR-
85 CQUIN was perceived by the staff responsible for achieving it at individual hospitals,
86 evaluate to what extent trusts made funding available to achieve it and finally explore
87 whether these factors had an impact on hospitals achieving reductions in antibiotic
88 consumption.

Methods

A web-based survey (www.surveymonkey.com) was developed, piloted with three hospital AMS leads and refined. The full survey is available in the supplementary materials. An email invitation to participate was sent to AMS leads at acute hospital NHS trusts on Dec 8th, 2016. The names and contact details used were compiled by one of the investigators (D-AO) as part of network development within ESPAUR. The people contacted had agreed to represent their organisations in communications with ESPAUR particularly related to the AMR-CQUIN activities. The survey was voluntary, two reminders were sent to recipients who didn't respond initially. No incentives were offered and there was no advertising of the survey. The survey asked for information about: AMS team structures and activity, the reductions needed to achieve each AMR-CQUIN component, whether funding was in place to achieve this and perceptions about the AMR-CQUIN. The survey closed to respondents on 5th March 2017. Where more than one survey was submitted from a hospital, the survey containing the greater number of completed fields was included. Any discordant answers were checked with the submitting hospital before removing the duplicate survey. In reporting the survey we have used the CHERRIES checklist for reporting results of Internet E-Surveys. [16] A completed checklist is available in the supplementary materials.

Hospital trust level data on antibiotic consumption were downloaded from ESPAUR using data submitted by acute hospital NHS trusts since 2013 using a standardised spreadsheet provided to organisations. Data extracted from the survey was analysed using SPSS Version 24 (IBM®, UK) and GraphPad Prism™. Categorical variables were compared using Fisher's exact tests and continuous variables using the Wilcoxon signed-rank test. According to current NHS Health Research Authority (HRA) guidance (available at www.hra.org.uk) ethical approval was not required for this study as this was a service evaluation of NHS staff. All antibiotic consumption data included was openly available.

Results

AMS at hospital trusts included in the survey

Responses were received from a total of 116/155 (75%) acute hospital trusts in England. The majority of surveys were completed by the lead antimicrobial pharmacist (64/116 [55%]), followed by another pharmacist (28/116 [24%]), the hospital lead-antimicrobial clinician (22/116 [19%]) and in two cases the infection prevention control nurse (2/116 [2%]).

108/116 (94%) respondents reported their hospital had an AMS committee which met quarterly or more often. AMS committees always included a microbiologist and antimicrobial pharmacist. Additional committee members varied with representation from acute medicine (78/116, 67%), surgery (64/116, 55%), paediatrics (49/116, 42%), intensive care (42/116, 36%), infection prevention director (47/116, 41%) and clinical commissioners / General Practice representatives (55/116, 47%). Microbiology / Infection trainee doctors were on the AMS committee in only 27/116 (23%) trusts.

NICE guidance on AMS processes and systems had been considered at the AMS committee in 108/116 (93%) trusts and 94/116 (81%) respondents reported completing the NICE AMS baseline audit tool which helps identify areas to improve compliance with the guidance. A total of 72/116 (62%) trusts had formally reviewed SSTF, a further 27/116 (23%) trusts had informally reviewed SSTF and 64/116 (55.3%) had an action plan for its implementation. Most respondents (105/116, 91%) reported that their trust had accessed the AMR Local Indicators data on 'Fingertips' and this data has been shared with their AMS committee (82/116, 71%), immediate colleagues (79/116, 68%), Trust Boards (37/116, 32%) or commissioners (33/116, 28%). Only six respondents (5%) indicated data had been shared with front-line clinical staff.

Achieving the CQUIN measures

Although the AMR-CQUIN aimed to achieve reductions of ≥1% compared to baseline (2013/14), in many trusts antibiotic consumption had continued to rise between 2013/2014 and the introduction of the AMR-CQUIN in April 2016. Consequently, most trusts needed to

achieve much larger reductions than ≥1% in in 2016/2017 compared with 2015/2016 (Table 1).

Changes in antibiotic use after introduction of the AMR CQUIN

Data gathered by ESPAUR from 130 acute hospital NHS trusts reporting annual data from 2013 onwards showed that increases in antibiotic use began to reverse in the 2015/2016 financial year, when trusts were first obliged to report usage data to ESPAUR (Figure 1). In that year, small but statistically significant year-on-year reductions were measured for total antibiotic use ($p<0.0001$), piperacillin/tazobactam use ($p<0.0001$) and carbapenem use ($p=0.05$). In the AMR-CQUIN year (ending March 2017) there was no evidence that total antibiotic consumption changed compared to the previous year +0.1% (-5.4, +4.0, $p=0.05$), but there were substantial and statistically significant reductions in piperacillin/tazobactam use of -4.8% (-16.9, +3.2, $p<0.0001$) and carbapenem use of-8.0% (-20.2, +4.0, $p<0.001$). However, there was striking variation between trusts. Changes in antibiotic consumption in 2016/2017 compared to a baseline of 2013/2014 ranged from -43% to +71% for total antibiotic use, -17% to +72% for piperacillin/tazobactam use and -79% to +44% for carbapenem use.

Of the surveyed trusts participating in the AMR-CQUIN, 41/111 (37%) achieved the quality measure for piperacillin/tazobactam, 61/111 (55%) for carbapenems and 48/111 (43%) for total antibiotic use (Table 2) based on information reported to PHE. The median reduction in antibiotic consumption compared to the 2013/2014 baseline achieved in those trusts surveyed was -0.2% (-11.9, +10.1) for total antibiotic use, +2.2% (-18.0, +18.3) for piperacillin/tazobactam and -7.8% (-29.4, +12.1) for carbapenems. The attitudes of AMS leaders to the AMR-CQUIN or availability of additional trust funding were not associated with achieving the CQUIN goals ($p>0.3$, Table 2). Substantially more trusts achieved the AMR-CQUIN where the survey respondents were optimistic about meeting the CQUIN ($p<0.0001$, Table 2).

Funding towards achieving the CQUIN

Five of the trusts surveyed reported a decision had been taken not to participate in the AMR-CQUIN. A total of 68/116 (59%) trusts set out to meet the nationally set CQUIN

reductions. Within the remaining trusts, 43/116 had negotiated local variations in some (18/116, 16%) or all (25/116, 22%) of the components. Funding had been made available to support achieving the AMR-CQUIN at only 23/113 (20%) participating trusts. Even where funding was made available in 18/23 (78%) trusts, the funding amount was <10% of the overall AMR-CQUIN value.

Perceptions and achieving the CQUIN

At the time the survey was conducted, the AMR-CQUIN had been in place for approximately 6 months. Respondents were pessimistic about achieving the targets, and only a minority felt their trust would achieve the necessary reductions for piperacillin/tazobactam (31/116, 27%), carbapenems (42/116, 36%) and total antibiotic use (34/116, 29%). Exactly half of the respondents (58/116, 50%) agreed with the statement that the AMR-CQUIN had changed AMS activity in their trust and 35/116 (30%) felt the AMR-CQUIN would reduce antibiotic consumption. However, only 22/116 (19%) felt that it would do so safely. Accordingly, 82/116 (71%) respondents were interested in the possibility of participating in research to evaluate how to safely optimize antibiotic review and revise.

Discussion

Reducing unnecessary antibiotic use among hospitalised patients is challenging because the need to ensure prompt effective empiric antibiotic treatment for patients with suspected life-threatening infection, coupled with fear of antibiotic resistance, drives increased use of the 'ultra-broad-spectrum' antibiotics that include piperacillin/tazobactam and carbapenems that have been linked to AMR. In the UK, NHS 'Start Smart then Focus' (SSTF) attempts to address this challenge by asking prescribers to regularly review and revise empiric antibiotic prescriptions. Similar approaches are applied in other European Countries [17]and in the United States.[18] Prescribers find review and revise is challenging.[19] Without robust measures to support it review and revise may not be effective in balancing drivers to increase use of broad-spectrum antibiotics in hospitalised patients.[20] It is encouraging that this survey has demonstrated not only a high level of awareness of NICE guidance and SSTF but also that over half the trusts now have an action plan for SSTF (55.3%) compared with 46% in 2014.[21]

Our findings that most hospitals have multidisciplinary AMS teams, meeting regularly who had considered the relevant NICE guidance and assessed their activity against it, all illustrate how well AMS is embedded in NHS hospitals, as it is elsewhere in high-income settings where regulatory measures are in force. [22] We did not gather detailed data on adequate staffing or specific action plans which have been highlighted as key gaps strategic needs in AMS programmes.[23] We were focused on the impact of the specific AMR-CQUIN intervention but our finding that so little new funding was made available even at trusts which achieved their targets suggests increased staffing was not a key factor.

A starting point for our study was concern that pharmacists and microbiologists responsible for AMS at individual hospitals doubted both the feasibility and safety of achieving the reductions required to achieve the CQUIN goals. By surveying the staff responsible for implementing AMS at acute trusts in England, we have determined that many staff did indeed have significant concerns about whether the AMR-CQUIN could be safely implemented. Although we did not explore the basis for concern, it is likely that prescribers are worried that efforts to reduce unnecessary antibiotic use may increase the risk of under-treatment of patients who need antibiotics. This is unsurprising given how few studies

assessing antimicrobial reduction strategies in hospitalised patients have included meaningful clinical outcome data.[24]

Many hospitals were confronted with needing to make much greater reductions in antibiotic use in 2016/2017 to achieve a >1% reduction in antibiotic use, because of year-on-year increases in antibiotic use from a baseline (2013/2014) set two years prior to the introduction of the AMR-CQUIN. Consequently, several trusts either elected not to try and achieve the goals as set out or, when they did, they were unwilling to allocate even a small amount of the money they would lose for not achieving them, to improve stewardship activity. Nevertheless, while neither concern about safety of the AMR-CQUIN nor lack of financial investment to achieve it appear to have impacted on the AMR-CQUIN being achieved, hospitals where staff were positive about its success were much more likely to achieve the reductions in antibiotic use required.

Our finding that only around half the hospitals surveyed achieved the antibiotic reduction targets is in striking contrast with the fact that ESPAUR data record that almost all trusts achieved the CQUIN target of 90% antibiotic prescriptions being reviewed.[14] However the explanation for this is likely to be that review more commonly results in continuing or changing treatment than discontinuation. ESPAUR data also report that only a small minority of antibiotic prescriptions are stopped at review and revise (nationally an average of 7.8% during the last quarter of the financial year 2016-17.[14] This in keeping with how hard prescribers find it to stop antibiotic prescriptions that have already been written.[19] Despite this, our data confirm that antimicrobial use in English hospitals started to decline in 2015/2016, the year that commissioners were first required to report antibiotic prescribing data from acute hospitals. This may be a 'Hawthorne effect', explained by an increased awareness and modification of prescribing habits by trust staff due to an increase in data collection in the year prior to the introduction of the quality improvement itself. While we find no overall further reduction in antibiotic use in the year the AMR-CQUIN was introduced, the marked reductions seen in piperacillin/tazobactam and carbapenem use suggests a move away from these two 'ultra-broad-spectrum' agents to alternatives, potentially increasing total antibiotic DDD by the use of more than one antibiotic.

Our study has limitations. Although the survey highlighted ongoing concern that the AMR-CQUIN may not be able to safely reduce antibiotic consumption we did not collect detailed information about the reasons for concerns. The survey was carried out six months after the AMR-CQUIN had started, which may have influenced respondents' perceptions about whether they would achieve the CQUIN. We sought a single response from each hospital and did not quality control the responses but respondents attested their leadership role in AMS at their trust and were asked to complete the survey in discussion with colleagues so we believe responses are likely to be reliable. Finally, we were not able to extract detailed information about the specific actions taken following introduction of the AMR-CQUIN which may have allowed individual trusts to achieve reductions, nor whether the total reductions resulted from shorter treatment durations or fewer patients being treated and whether overall appropriateness of treatment improved. There is a need for future work to understand these mechanisms better to support antibiotic optimization more widely.

Despite these limitations, our findings indicate that the AMR-CQUIN approach of setting goals backed up by robust data gathering and reporting has helped hospitals achieve reductions in antibiotic overuse. Positive staff attitudes rather than availability of new funding are likely to have been important at hospitals which achieved the reduction goals. Further efforts to improve review and revise decision making as a key element of hospital AMS practice will need both evidence and novel tools to support clinical decision and reassure staff that patient safety is not compromised when stopping unnecessary antibiotics.

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Transparency declarations

None to declare

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References

1. Albrich WC, Monnet DL, Harbarth S. Antibiotic Selection Pressure and Resistance in Streptococcus pneumoniae and Streptococcus pyogenes. *Emerg Infect Dis* 2004; **10**: 514–7.

2. Costelloe C, Metcalfe C, Lovering A, *et al.* Effect of antibiotic prescribing in primary care on antimicrobial resistance in individual patients: systematic review and meta-analysis. *BMJ* 2010; **340**: c2096.

3. Zarb P, Amadeo B, Muller A, *et al.* Identification of targets for quality improvement in antimicrobial prescribing: the web-based ESAC Point Prevalence Survey 2009. *J Antimicrob Chemother* 2011; **66**: 443–9.

4. G7 2016 in Japan: PM press statement - GOV.UK. Available at: https://www.gov.uk/government/speeches/g7-2016-in-japan-pm-press-statement.

5. National_action_plan_for_combating_antibotic-resistant_bacteria.pdf. (2015) Available at: https://www.idsociety.org/uploadedFiles/national_action_plan_for_combating_antibotic-resistant_bacteria.pdf.

6. English Surveillance Programme for Antimicrobial Utilisation and Resistance (ESPAUR) - ESPAUR_report_2017.pdf. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/656611/ESPAUR_report_2017.pdf.

7. Sepsis: recognition, diagnosis and early management | Guidance and guidelines | NICE. Available at: https://www.nice.org.uk/guidance/ng51.

8. Gilchrist M, Wade P, Ashiru-Oredope D, *et al.* Antimicrobial Stewardship from Policy to Practice: Experiences from UK Antimicrobial Pharmacists. *Infect Dis Ther* 2015; **4**: 51–64.

9. The Health and Social Care Act 2008: code of practice on the prevention and control of infections and related guidance - GOV.UK. Available at: https://www.gov.uk/government/publications/the-health-and-social-care-act-2008-code-of-practice-on-the-prevention-and-control-of-infections-and-related-guidance

10. Ashiru-Oredope D, Sharland M, Charani E, *et. al.* ARHAI Antimicrobial Stewardship Group. Improving the quality of antibiotic prescribing in the NHS by developing a new Antimicrobial Stewardship Programme: Start Smart--Then Focus. *J Antimicrob Chemother* 2012; **67 Suppl 1**: i51-63.

11. English Surveillance Programme for Antimicrobial Utilisation and Resistance (ESPAUR) - ESPAUR_report_2015.pdf. Available at: ESPAUR_Report_2015.pdf. Available at: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/477962/ESPAUR_Report_2015.pdf.

12. Quality Premium guidance 2015-16v3 - qual-prem-guid.pdf. Available at: https://www.england.nhs.uk/wp-content/uploads/2013/12/qual-prem-guid.pdf

13. NHS England » Anti-Microbial Resistance (AMR) CQUIN. Available at: https://www.england.nhs.uk/nhs-standard-contract/cquin/cquin-16-17/amr-cquin/.

14. Public Health England. *AMR local indicators* . Available at: https://fingertips.phe.org.uk/profile/amr-local-indicators.

15. Johnson AP, Muller-Pebody B, Budd E, *et al.* Improving feedback of surveillance data on antimicrobial consumption, resistance and stewardship in England: putting the data at your Fingertips. *J Antimicrob Chemother* 2017; **72**: 953–6.

16. Eysenbach G. Improving the Quality of Web Surveys: The Checklist for Reporting Results of Internet E-Surveys (CHERRIES). *J Med Internet Res* 2004; **6**. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1550605/.

17. Howard P, Huttner B, Beovic B, *et al.* ESGAP inventory of target indicators assessing antibiotic prescriptions: a cross-sectional survey. *J Antimicrob Chemother* 2017; **72**: 2910–4.

18. Core Elements of Hospital Antibiotic Stewardship Programs | Antibiotic Use | CDC. 2017. Available at: https://www.cdc.gov/antibiotic-use/healthcare/implementation/checklist.html.

19. Charani E, Castro-Sanchez E, Sevdalis N, *et al.* Understanding the determinants of antimicrobial prescribing within hospitals: the role of 'prescribing etiquette'. *Clin Infect Dis* 2013; **57**: 188–96.

20. Llewelyn MJ, Hand K, Hopkins S, *et al*. Antibiotic policies in acute English NHS trusts: implementation of 'Start Smart-Then Focus' and relationship with Clostridium difficile infection rates. *J Antimicrob Chemother* 2015; **70**: 1230–5.

21. Cooke J, Stephens P, Ashiru-Oredope D, *et al.* Antibacterial usage in English NHS hospitals as part of a national Antimicrobial Stewardship Programme. *Public Health* 2014; **128**: 693–7.

22. Dyar OJ, Tebano G, Pulcini C, *et al*. ESGAP (ESCMID Study Group for Antimicrobial stewardshiP). Managing responsible antimicrobial use: perspectives across the healthcare system. *Clin Microbiol Infect* 2017; **23**: 441–7.

23. Pulcini C, Morel CM, Tacconelli E, *et al.* Human resources estimates and funding for antibiotic stewardship teams are urgently needed. *Clin Microbiol Infect* 2017; **23**: 785–7.

24. Schuts EC, Hulscher MEJL, Mouton JW, *et al.* Current evidence on hospital antimicrobial stewardship objectives: a systematic review and meta-analysis. *Lancet Infect Dis* 2016; **16**: 847–56.

Table 1. Reductions in antibiotic use required to achieve the AMR-CQUIN targets. Of those trusts surveyed, data was available for 107/116 trusts for piperacillin/tazobactam and carbapenems and for 108/116 trusts for total antibiotic consumption.

Antibiotic reductions needed to achieve AMR-CQUIN (%)	Piperacillin/tazobactam n=107 (%)	Carbapenems n=107 (%)	Total antibiotic n=108 (%)
<1%	11 (10%)	23 (21%)	17 (16%)
1-5%	14 (13%)	14 (13%)	24 (22%)
5-10%	11 (10%)	8 (7%)	19 (18%)
10-20%	23 (21%)	15 (14%)	21 (19%)
>20%	25 (23%)	24 (22%)	5 (5%)
Not known	23 (21%)	23 (21%)	22 (20%)

Table 2. Impact of funding and attitudes on Trusts achieving the AMR-CQUIN. (a) 3 respondents did not answer this question. (b) 39 respondents were unsure whether the CQUIN would reduce antibiotic consumption and 13 did not answer this question. (c) 19 respondents were unsure whether the CQUIN had changed AMS and 11 did not answer this question (d) 57 respondents were unsure whether the CQUIN would safely reduce antibiotic consumption and 11 did not answer this question (e) In total 26, 28 and 29 respondents did not answer this question for piperacillin/tazobactam, carbapenems and total antibiotics respectively.

	Piperacillin/tazobactam (n=109)			**Carbapenems (n=109)**			**Total antibiotic (n=108)**		
	Achieved n=41 (%)	**Not Achieved n=68 (%)**	**p**	**Achieved n=61 (%)**	**Not Achieved n=48 (%)**	**p**	**Achieved n=48 (%)**	**Not Achieved n=60 (%)**	**p**
Funding[a] available (n=23)	10 (24%)	13 (19%)	0.63	16 (26%)	7 (15%)	0.32	11 (23%)	12 (20%)	0.60
Funding not available (n=90)	30 (73%)	53 (78%)		43 (70%)	40 (83%)		36 (75%)	46 (77%)	
CQUIN will help reduce antibiotic consumption [b] (n =35)	16 (39%)	16 (24%)	0.34	18 (30%)	15 (31%)	0.94	14 (29%)	18 (30%)	0.96
CQUIN will not help reduce antibiotic consumption (n=29)	11 (27%)	16 (24%)		15 (25%)	12 (25%)		10 (21%)	17 (28%)	
CQUIN will change AMS [C]	21 (51%)	32 (47%)	0.84	22 (36%)	30 (63%)	0.42	30 (63%)	23 (38%)	0.53
CQUIN will not change AMS[C]	10 (24%)	17 (25%)		15 (25%)	12 (25%)		12 (25%)	15 (25%)	
CQUIN will safely reduce antibiotic consumption [d]	6 (15%)	14 (21%)	0.87	7 (11%)	13 (27%)	0.87	8 (17%)	12 (20%)	0.99
CQUIN will not safely reduce antibiotic consumption [d]	11 (27%)	13 (19%)		10 (16%)	14 (29%)		10 (21%)	14 (23%)	
Trust predicted that they would achieve CQUIN [e]	26 (63%)	2 (3%)	<0.0001*	40 (66%)	1 (2%)	<0.0001*	31 (65%)	1 (2%)	<0.0001*
Trust predicted that they	6 (15%)	53 (78%)		4 (6%)	42 (88%)		5 (10%)	48 (80%)	

would not achieve CQUIN [e]									

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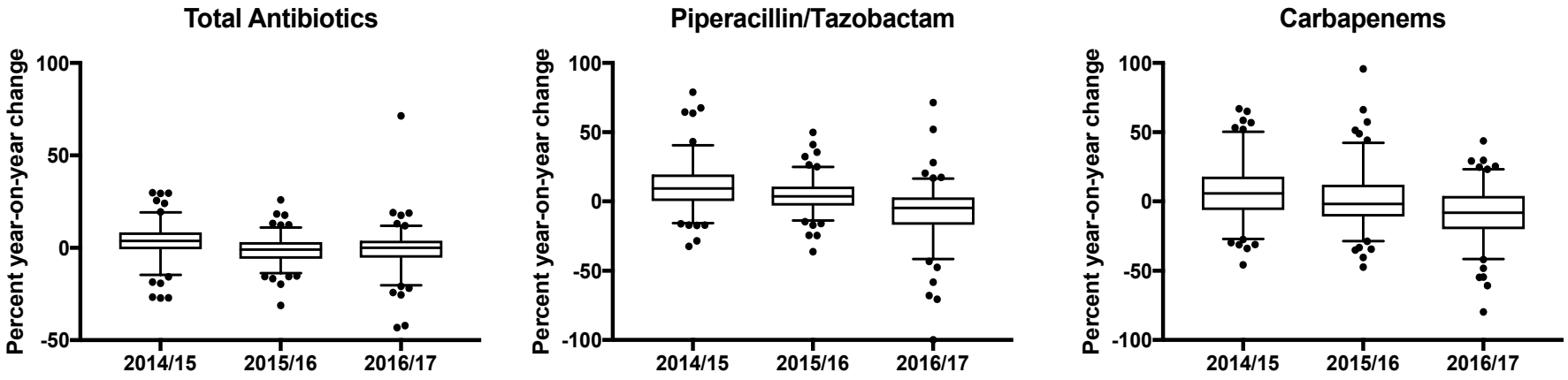
Figure 1. Year-on-year changes in antibiotic use at acute hospitals in England. Boxes show medians and quartiles, whiskers 5 and 95 percentiles. P values are Wilcoxon sign rank, 2-tailed.



	2014/15	2015/16	2016/17
25th percentile	-0.8	-6.0	-5.4
Median	3.7	-1.0	0.1
75th percentile	8.4	3.2	4.0

P<0.0001 P=0.05

	2014/15	2015/16	2016/17
25th percentile	0.2	-3.2	-16.9
Median	9.4	3.7	-4.8
75th percentile	19.5	10.8	3.2

P<0.0001 P<0.0001

	2014/15	2015/16	2016/17
25th percentile	-6.2	-11.0	-20.2
Median	5.8	-1.7	-8.0
75th percentile	18.2	12.3	4.0

P=0.05 P<0.001